# BELL TELEPHONE QUARTERLY

VOL. XVI APRIL, 1937 NO. 2

MEETING THE CHALLENGE OF SLEET AND FLOOD

THE TELEPHONE BUSINESS OFFICE

LANGUAGE AND THE TELEPHONE ART

SCIENCE RESEARCH IN ELECTRICAL COMMUNICATION

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# BELL TELEPHONE QUARTERLY

*A Medium of Suggestion and a Record of Progress*

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*Address all communications to*

INFORMATION DEPARTMENT
AMERICAN TELEPHONE AND TELEGRAPH COMPANY
195 Broadway, New York

# Contributors to This Issue

JUDSON S. BRADLEY

Yale University, B.A., 1918. Private, U. S. Army Ambulance Service with the Italian Army, 1917–19. Assistant editor, managing editor, *The Yale Alumni Weekly*, 1920–24. Southern New England Telephone Company, copy manager, advertising manager, 1925–28. American Telephone and Telegraph Company, Department of Operation and Engineering, Sales Section, 1928–30; Information Department, 1930–.

ROBERT P. JUDY

Pomona College, B.A., 1920. Associated Oil Company of Wyoming, Purchasing Agent, 1920–22. Southern California Telephone Company, Commercial Department, 1922–27. American Telephone and Telegraph Company, Department of Operation and Engineering, Commercial Division, 1927–; Commercial Results and Practices Engineer, 1934–.

FRANK B. JEWETT

Throop Polytechnic Institute (now California Institute of Technology), B.A., 1898; University of Chicago, Ph.D., 1902. Several honorary degrees. Instructor in Physics and Electrical Engineering, Massachusetts Institute of Technology, 1902–04. American Telephone and Telegraph Company, Transmission and Protection Engineer, 1904–1912; Western Electric Company, Assistant Chief Engineer, Chief Engineer, Vice President, 1912–25; Vice President, American Telephone and Telegraph Company, in charge of Development and Research Department, and President, Bell Telephone Laboratories, 1925–.

STERLING PATTERSON

Yale University, Ph.B., 1915. Reporter, *New York Tribune*, 1915–17. First Lieutenant, U. S. Air Service, 1917–19. Western Electric Company, Public Relations Department, and Editor, *Western Electric News*, 1919–30; Editorial Director, 1930–33. American Telephone and Telegraph Company, Information Department, 1933–.

# Meeting the Challenge of Sleet and Flood

NATURE smote the Ohio River valley with heavy hand late in January, bearing hardship, suffering, destruction and death on flood waters which in the lower part of the river reached levels never before known. Cities, towns, hamlets, cross-roads settlements alike experienced the devastating force of a mighty stream gone berserk.

The floods in the Spring of 1936 covered a wider geographical area, exacting their toll from Maine to Maryland and the Virginias as well as along the Ohio. It was the communities along the upper reaches of that river and its tributaries which suffered then; this year, by contrast, it was principally from below Wheeling, W. Va., to the confluence with the Mississippi that the sullen, murky flood reared its crest to new heights, spread further to each side its greedy inundation.

Fortunately, ours is not only a vast country but a unified one. The same newspapers which carried early accounts of the misery and loss in the stricken territory carried also reports of the immediate, orderly, far-flung mobilization of every means to bring it aid: not only National Guard units and, in some instances, Federal troops, but the Coast Guard, the Public Health Service, Army Engineers, CCC and WPA workers and, as a matter of course, the Red Cross. Mobilized also, and equally as a matter of course, were the resources—the man-power, the supply service, the productive capacity and the operating, engineering and administrative capabilities—of the Bell System.

Well do the men and women of the Bell System know that catastrophe places upon them a double responsibility; for the same forces which inflict damage and destruction on all other property are no more sparing of telephone plant, while bringing at the same time all the more urgent need for communica-

tion. So with this flood: telephone calls within, into, and out of the affected areas by individuals, by industry, by the press, by the arms of rescue and rehabilitation multiplied many-fold, making abnormal demands upon plant which, because of damage, was in certain cases and for longer or shorter periods inadequate to provide even normal service.

So they swung into action on a front that included not only the flood area but such distant points as New York City and Jacksonville, Chicago and New Orleans: operators, plant men, engineers, commercial department people, executives, in the operating companies; Long Lines repair and maintenance men, repeater attendants, operators, traffic and circuit engineers; manufacturing, distributing, transportation, installation forces in the Western Electric Company; power supply and other specialists from the Bell Laboratories; and, in the A. T. and T. Co. headquarters organization, those who could best advise on problems anticipated or to be met.

### Mobilization for the One Great Task

A systematic mobilization of man power—*and* woman power —was directed at these three aspects of the one great task: To take in advance every possible precaution to protect the equipment and the service against the flood. If and when these precautions are unavailing, to maintain the service as long as power and a switchboard and a line are left to use and one person left to use them. And, if the waters are finally victorious wholly or in part, the plant is crippled or goes dead and service is greatly curtailed or suspends, to restore the plant and resume the service at the earliest moment humanly possible.

On the Ohio, in the early days of February, there might have been seen at one time stirring, determined, wearying efforts to achieve all three of those objects.

In the cities and towns first affected, where now the flood was receding, the work of restoration was in full swing: equipment was being dried out, or replaced from emergency ship-

ments; the huge task of inspecting, repairing, renewing outside plant was surging ahead with augmented forces, which were in turn receiving the full support of the service of supply; the entire effort, through long hours of work along predetermined lines, was to restore the service to normal with the least possible delay.

Further down the river, the second stage of the battle was in progress: to hold out or to pump out the water—to protect the equipment by any and every means—to keep as many lines up as might be or to establish emergency circuits when all others had failed—to man the switchboards as long as calls could go through. In many a central office so circumstanced, operators, plant men, and others either slept and ate within the building or resorted to boats for transportation; stores of food and sometimes of water were laid up; emergency generators furnished the power or stood ready to be hooked up; and safe exit for all by boat or other means was instantly available if the fight must become, after all, flight.

### Waiting—and Keeping the Service Going

Still lower in the Ohio River Valley, as at Cairo, Ill., for example, where the waters lingered for days a scant six inches below the top of the city's 60-foot sea wall while the second floor of the central office is at a level equivalent to the 54-foot stage of the river, the first phase of the fight against the flood was taking place: preparation. Here everything had been done that could be done. Records and equipment were moved, emergency power was provided against need, men and women knew their individual duties should there come the sound of the flood alarm, transportation to safety was at hand. There remained only to furnish telephone service to Red Cross, National Guard, army engineers and the other forces of rescue and relief in the evacuated city—and to wait. Just wait. Wait until, at long last, the river's level began to fall, slowly, almost

imperceptibly, and word went forth that the immediate danger was past.

And below Cairo? Below Cairo is the Mississippi. What of *it?* Why, from Cairo to New Orleans pretty much the same story: foresight, preparation, watchful waiting. From the Ohio to the Gulf, means and men are at hand to protect equipment, to maintain circuits, against a crest full 10 feet higher than there is slightest likelihood that even this greatest of all floods will reach.

That, then, is in broad perspective the view which early February discloses. The aftermath will be written in days and weeks and months of anxiety, of unremitting labor, of problems met, faced, overcome. The sequel will be told, without fanfare, in normal telephone service.

### Nature's First Onslaught Was with Sleet

The flood was Nature's second onslaught in quick succession, however, not the first—at any rate so far as concerns the telephone system and its business of carrying messages. As a series of curtain raisers to the Ohio River's savage outbreak, multiple sleet storms struck heavily over an area coinciding in part with that which was later to suffer from the rising waters but extending for many hundreds of miles beyond it.

Sleet! It rarely makes newspaper headlines, except for local summaries of transportation and communication facilities interrupted. It causes relatively little damage to property in general, it seldom disrupts social and commercial life, it drives before it no horde of hapless refugees, as does a major flood. But of the continuing flow of intercommunication—the pulsing of the relationship between one group, one place, and another —over open wire lines, sleet is, by and large, the most relentless enemy.

From the early days of January up even to the start of the flood emergency, sleet storms—in some territories three or more, in others two, and in some only one—laid wires in icy

tangles and poles in splintered rows across a big part of the country. The area affected forms a wide swath extending from southwestern Texas in a northeasterly direction across parts of Oklahoma, Kansas, Arkansas, and Missouri; into a corner of Iowa; across west central Illinois and the lower part of Indiana; and along the western sections of Tennessee and Kentucky.

### The Storms Did Enormous Damage

The damage to telephone plant by this succession of sleet storms was tremendous. In the territory of the Southwestern Bell Telephone Company alone, as the result of the first sleet storm, 25,000 poles were down or broken over an area of 175,000 square miles, 2,500 toll circuits were out of service, 60 towns were isolated at one time or another, and 710,000 spans of wire (18,000 wire miles) would have to be replaced before repairs were complete. Subsequent sleet storms, although less wide-spread, did additional damage. Some 2,000 plant men, including crews rushed into the area from adjoining Bell System companies, were called on to undertake restoration of the damage. The same storm, striking the western section of Illinois Bell territory, took down nearly 3,000 poles, isolating a number of important toll centers as well as causing many exchange wire breaks. If the damage from this and subsequent sleet storms was less heavy in the territories of the other Associated Companies affected, it was principally because they were there less wide-spread. And there were many instances of tired plant gangs, working long hours to restore the service to full usefulness after one sleet storm, which were called on to do again much of what they had recently accomplished, or to rush to another section of the territory to restore service on an emergency basis, as one storm followed another.

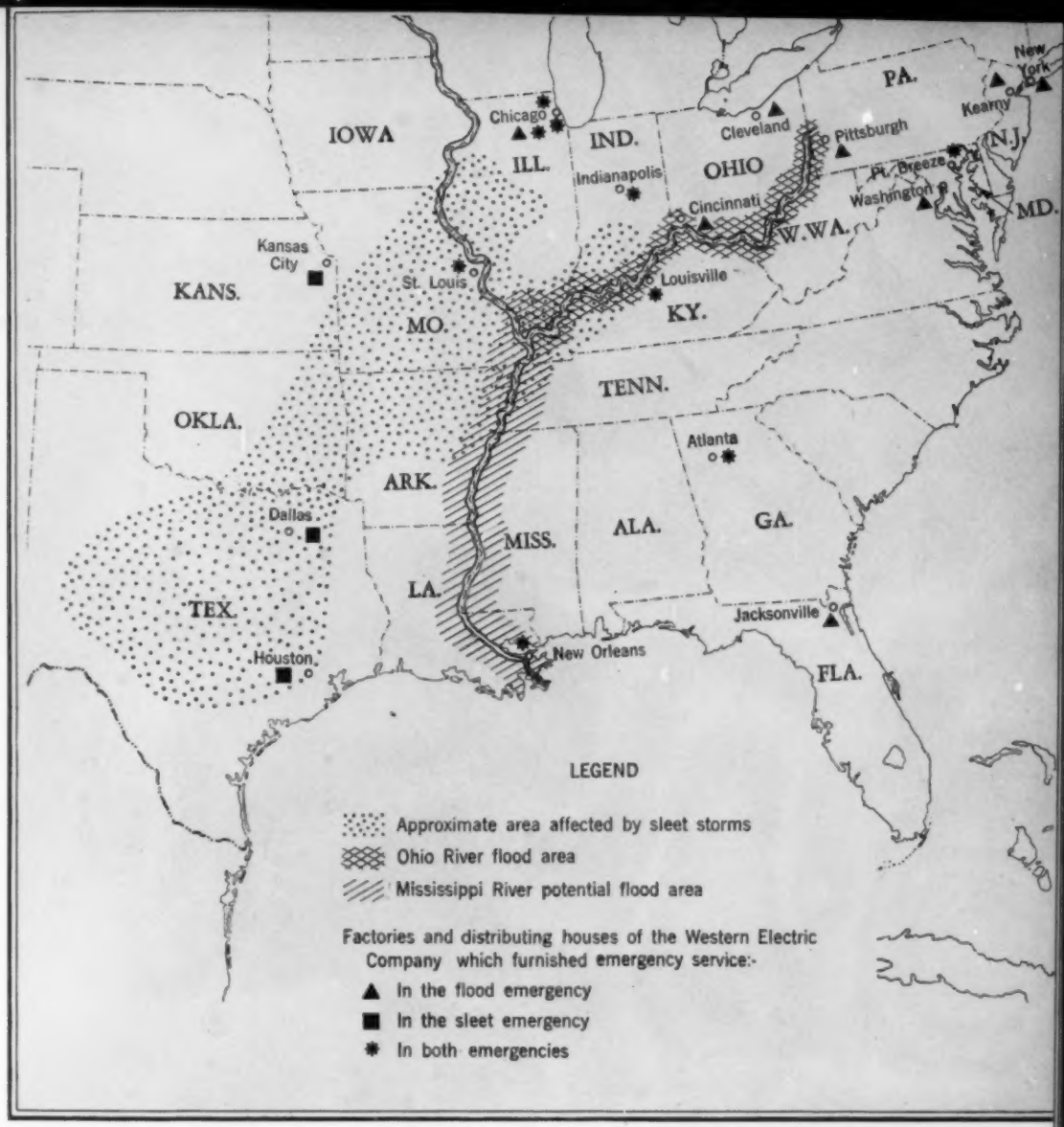
Throughout this whole vast sleet-ridden area, rapid surveys of damage were followed by the assignment of plant forces summoned from far and near to meet the critical necessity of

restoring service. Closely coördinated with this rallying of man power were the emergency shipments from Western Electric factories and distributing houses straight to the points of greatest need: poles and cross arms by the thousands, line and pole hardware by tons, innumerable thousands of feet of wire, other equipment as needed and on demand, speeding by truck and train to those places in the stricken area where they were most sorely needed. Standardized items all, ready to take their place and do their part anywhere in the Bell System, and ready also to the hand of any Bell-trained man, no matter from what section of the country nor from which Operating Company he had been dispatched to help in the restoration of the service. Men and supplies! The ones schooled and the others manufactured to work together, as is the Bell System way, together they can confront, can overcome even so far-flung a test of skill and resources as last January's sleet.

## Weary Men Who Faced the Flood

That, obviously, is but a moment's glance at the vast picture of the sleet storms and what they did. The whole story cannot possibly be told now, any more than can a comprehensive account of the flood which followed. So much is given here because it forms in part a background to the story of the flood. For it was in many cases those same plant men, weary from days and even weeks of heavy work in restoration of sleet damage—the same foremen, supervisors, executives—the same companies and territories, in other words, which were confronted with a flood of size and force never before known.

For the full length of the Ohio River, the flood story can be narrated in terms of damage done: of lines under water or washed out, of central offices partly flooded or almost wholly inundated or even carried away; of service continued under the utmost difficulty and often danger, and of service suspended for a while when there remained no longer any means to give it; of work carried on through utterly trying circumstances,




*THE photographs on the following pages have been selected from several hundred in an attempt to visualize for the reader something of the conditions which prevailed over a large part of the middle West during last January and February, from the onslaught of the sleet through the several stages of the battle against flood waters. As illustrations for the article "Meeting the Challenge of Sleet and Flood," they were not chosen as typical of the situation in the territory of any one telephone company but as representative of the conditions faced, in greater or less degree, by eight Bell System operating companies. They tell, as adequately as is possible in limited space, the story of the loyalty to the service that is traditional with Bell System workers, save for one important omission: operators' work under stress does not lend itself to pictorial treatment, and their faithfulness and courage cannot be captured by the lens.*

*Desolation in much of Northern Missouri was sleet's aftermath.*

*It was cold in Indiana as, entering the sleet zone, this line gang stopped to put chains on their truck.*

*Four cross-arms of this terminal pole just outside Quincy, Ill., succumbed to the gleaming sleet which has no beauty in a plant man's eyes.*

*Heavy was Nature's burden the wires bore. These are in Camp Point, Ill.*

*Atop a pole near Moberly, Mo.*

*Why the wires went down in Indiana.*

*Emergency shipments leaving Western Electric's Hawthorne Works by night for sleet-stricken areas. Left: drop wire for Louisville, Ky. Right: line wire for Quincy, Ill.*

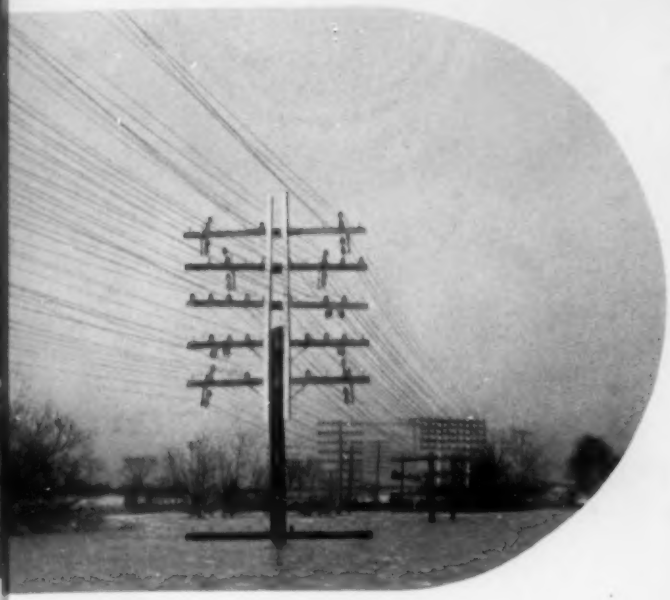
*Long Lines Plant crews raising circuits north of Cairo, Ill., by bolting extensions to the tops of the poles or relocating crossarms in preparation for possible high water.*

*A pickle barrel kept this Pittsburgh P.B.X. out of high water—and trouble.*

*Business as usual through this P.B.X., with trunks cut through on night connections to second floor extensions.*

*With water 18 inches deep on the Point Pleasant, W. Va., central office floor, the messages still went through.*

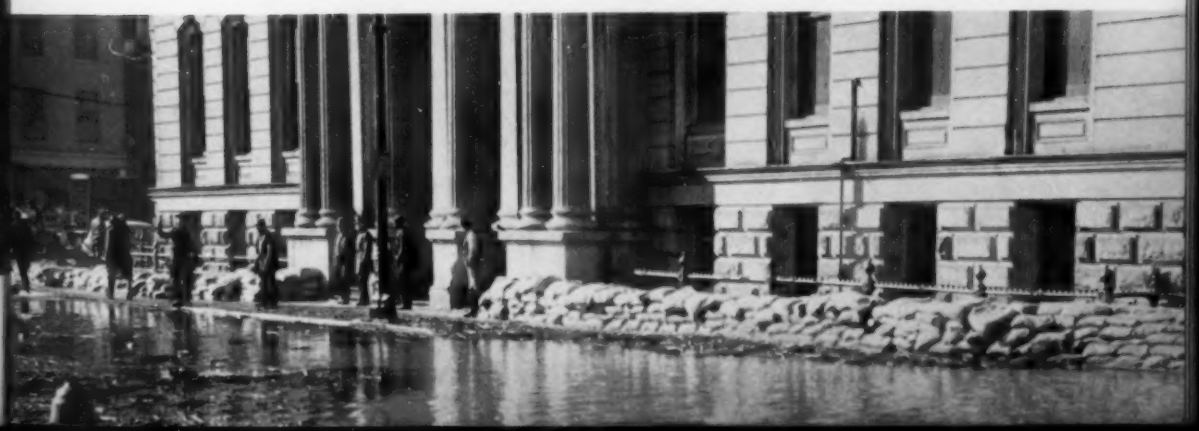
*With cross-arms raised three times, these Long Lines circuits near New Albany, Ind., were kept out of trouble at this point.*



*Up she comes!*

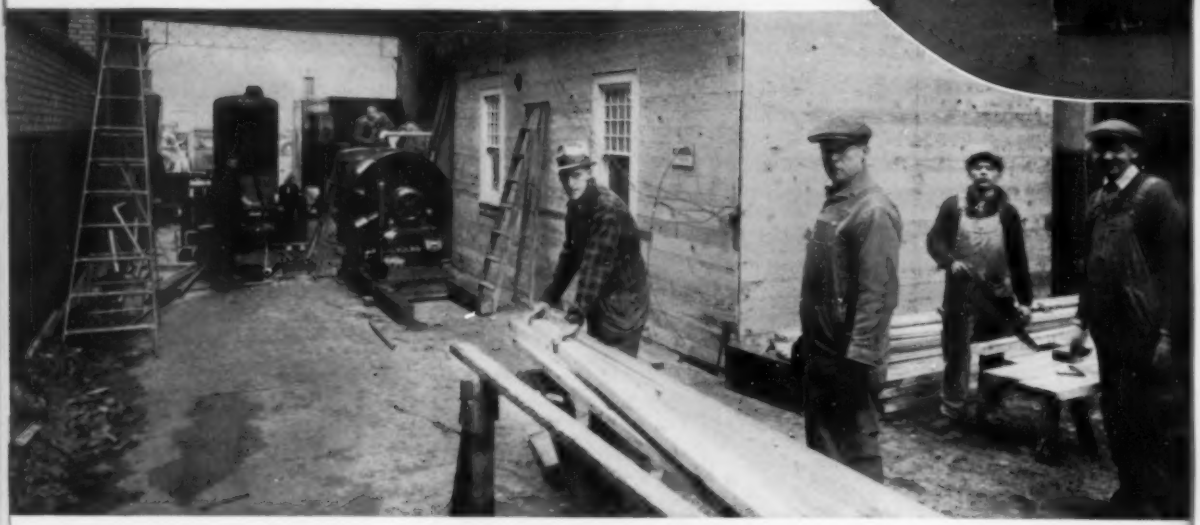
*Swinging the main frame up to the ceiling made it possible to maintain service at Marietta, O.*

*This sand-bag dyke protected the telephone equipment in the basement of Louisville's City Hall from advancing waters.*



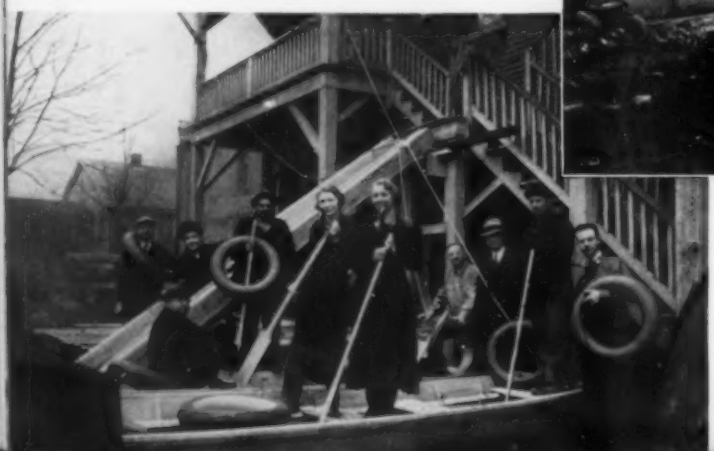
*Unloading emergency power equipment from Harriman, Tenn., at Beuchell for transportation to Louisville by truck.*

*Placing temporary batteries on the second-story porch in the rear of the Cairo, Ill., central office.*

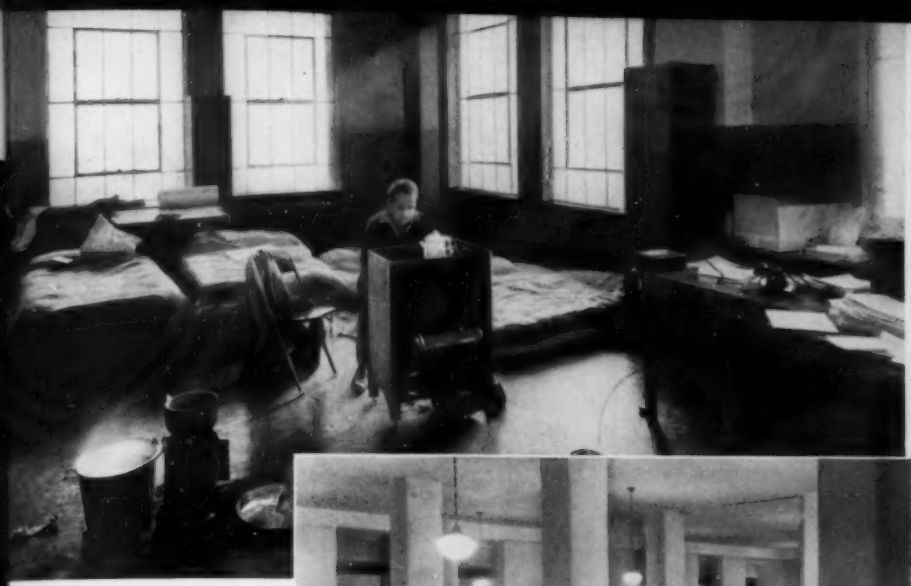


*This shed was built to house emergency motor generators rushed to Cincinnati from LaGrange, Ind., and Milwaukee, Wis.*

*Boats and improvised life belts were included among the preparations in Cairo, Ill., against the eventuality that the water might overtop the sea wall.*



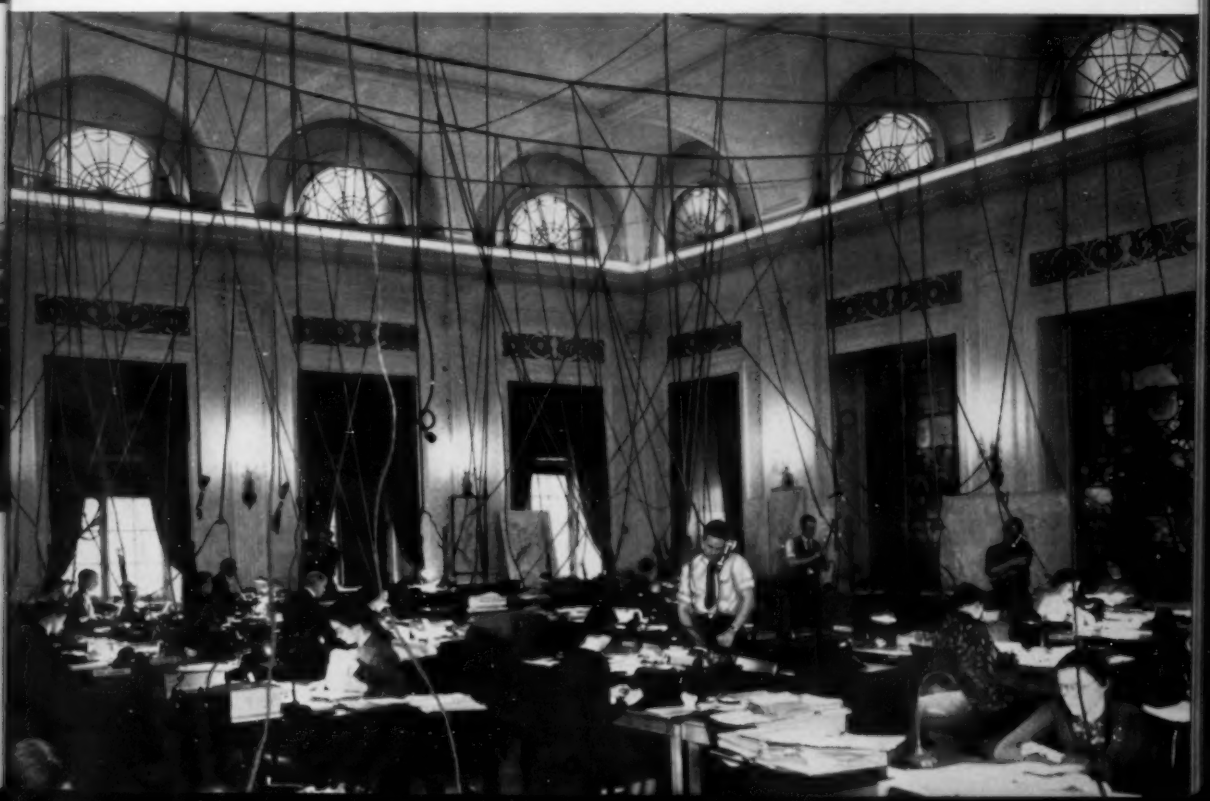
*Not the scene of trench warfare, but the west side of the Jackson-Wabash central office building in Louisville after sand-bags had been filled there.*



*Three men lived for a week on the second floor of the Western Electric Company's Louisville distributing house while water invaded the first floor, receiving orders by telephone and dispatching them by boat.*

*Many of the companies affected by the flood set up special organizations to deal with the emergency. This group pictured in Indianapolis was soon moved to Jeffersonville, close to the scene of action.*

*When flood relief assumed major proportions, the disaster staff of the Red Cross took over the Assembly Hall at National Headquarters in Washington. Telephones were quickly provided by stringing cables from wall to wall overhead and dropping wires to the desks. In this picture the installers are still at work.*



*The Red Cross supplied the boat these Long Lines men are using along the Memphis-Little Rock toll lead.*

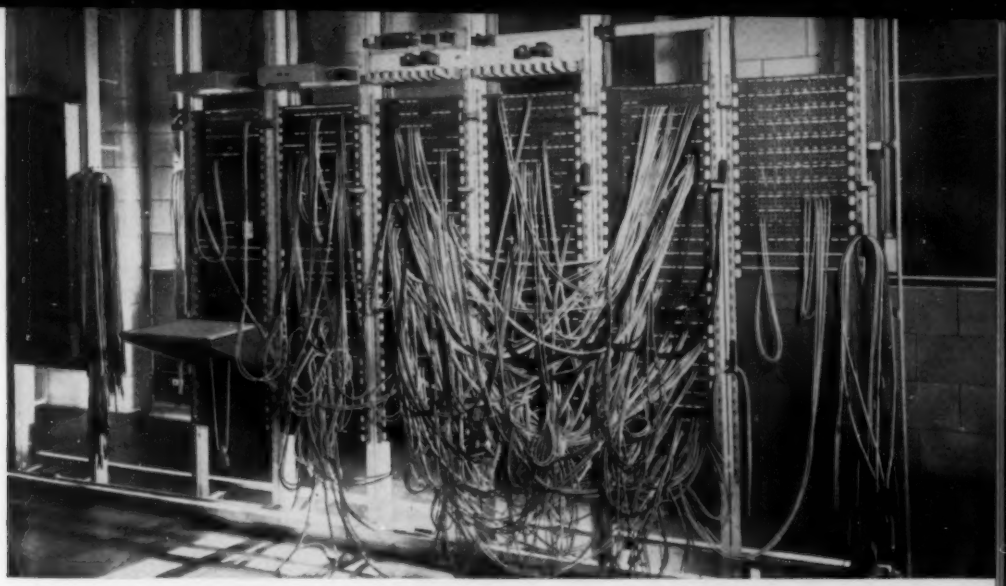
*Nautical hitch-hiking.*

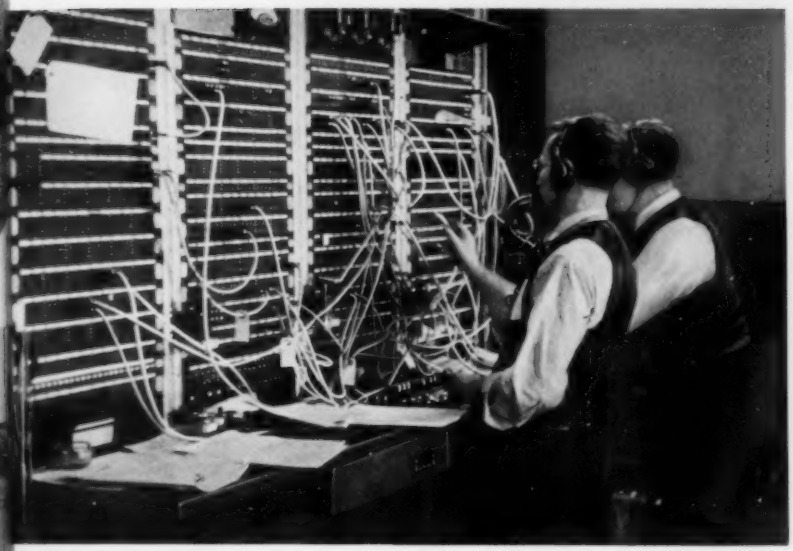
*Stout fella!*

*The good ship "Bell Telephone Long Lines" is beached for temporary repairs.*

*Stringing drop wire in Marietta, O.*

*The Long Lines patching jack board in Cincinnati at the height of the flood.*





*The Long Lines test panel in Cairo, Ill.*

*Sand-bags and pumps kept the water-level down in the office manhole outside the Evansville, Ind., telephone building. Above, at the right, is how it poured in.*

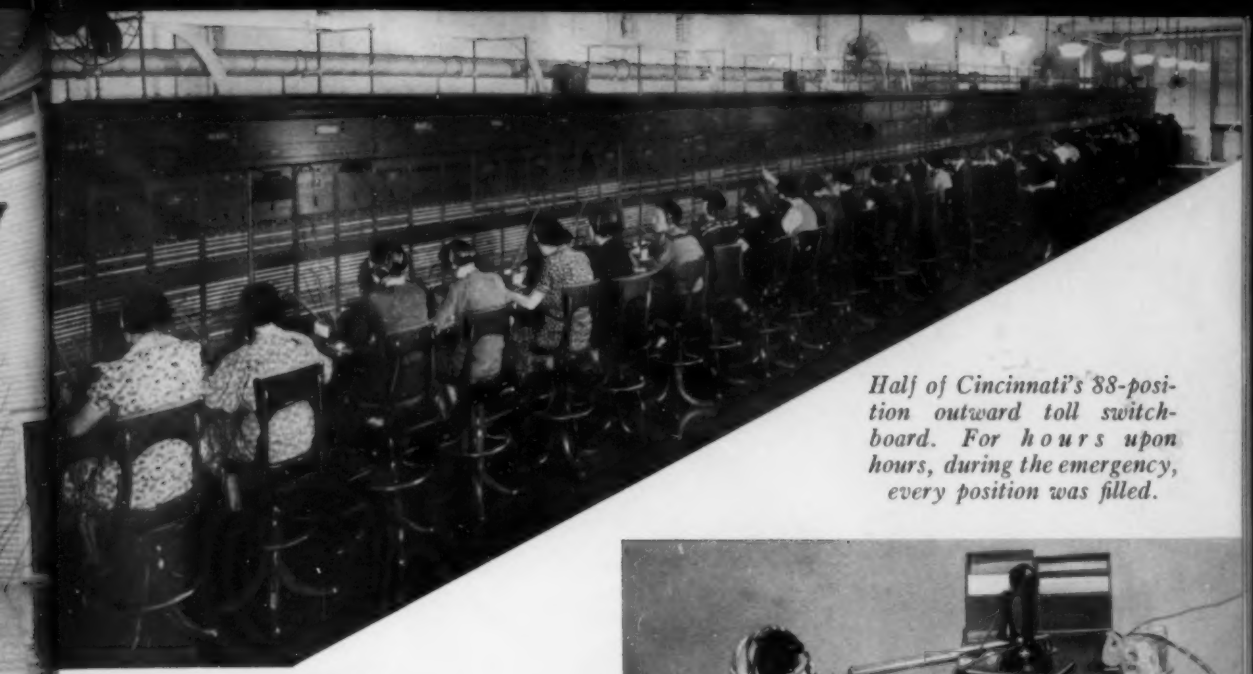
*Operators reporting for duty in Marietta, O.*

*This operator clambered up the fire-escape and through the window into the central office in Jeffersonville, Ind. Next day, leaving, she stepped out of the window directly into a boat.*

*Supplies entering the second-floor central office in Mound City, Ill. Although the town was practically evacuated, service was maintained to aid in relief and levee patrol work.*

*Heal phon affec inoc*

*Boatmen rowing operators away from the Jeffersonville central office in a downpour, after orders had been received that the office be evacuated.*



*Half of Cincinnati's 88-position outward toll switchboard. For hours upon hours, during the emergency, every position was filled.*

(ACME NEWS PHOTO)

*This P.B.X. operator in a hotel in Portsmouth, O., carried on in the same spirit as her sister operators throughout the flood area.*

*Health precautions for telephone people throughout the affected territory included inoculation against typhoid.*

*Temporary dormitories were generally provided for operators whose homes were flooded out or for whom high water made transportation difficult or dangerous. This picture was taken in Evansville, Ind.*

*Truck convoy waiting at the railroad for the arrival of emergency supplies for Louisville.*

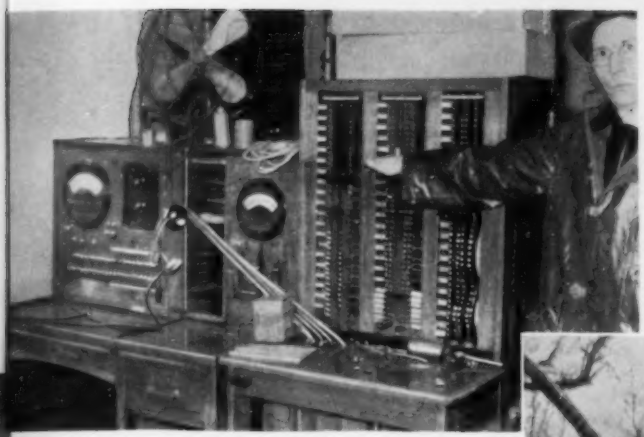
*Tank trucks delivering water in Cincinnati for use in boilers and for cooling emergency charging sets.*

*With no electric power in Louisville, a truck winch hoists food and water to the ninth floor.*

*Pickaback to restore a subscriber's service.*

*"Low bridge" through the telephone building's front door in Marietta, O.*

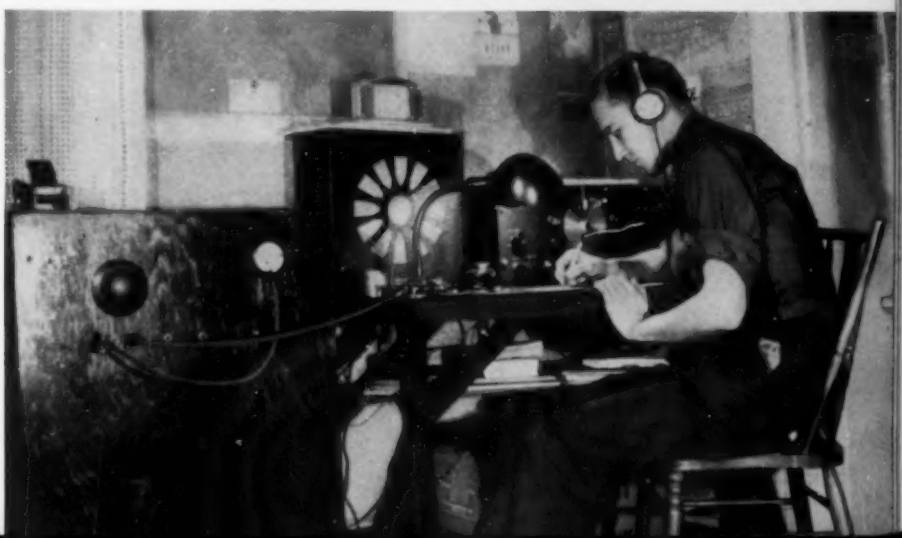
*Impromptu cafeteria set up in Evansville, Ind., to provide hot food during the flood emergency.*



*Borne by raging current, this tree-trunk threatened to demolish the house in the background, at Cypress, Ind. Telephone men working nearby snapped a steel cable around it, shown at left of picture, and anchored it securely to a sturdy tree.*

*"Up to here" went the water on the New Albany, Ind., test desk.*

*Many telephone men were among the licensed amateur radio operators who relayed relief and rescue messages. Among them was this St. Louis Western Electric installer, owner of his own amateur station and a member of the Naval Communication Reserve.*



*Lines must be cleared of debris left by receding waters.*

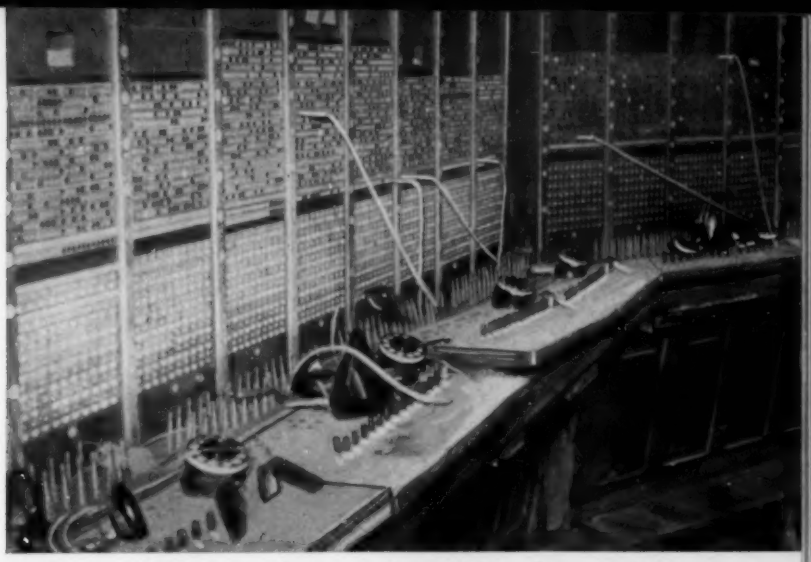
*Battered victim.*

*Leaning poles show with what force houses, barns, boats and miscellaneous flotsam were washed through this Southern Bell line.*

*Following the water's devastation comes the scourge of muck. This scene, which might be anywhere in the flood's wake, happens to be in Louisville.*

*House*

*Water goes but trouble remains on the Gallipolis-Portsmouth line.*



*Water rose above the key shelf in the second-floor operating room in Jeffersonville, Ind.*

*Plant Department quarters in New Albany, Ind. The high-water level leaves its record on the wall.*

*House Service that calls for shovel and hoe.*

*Western Electric's installation forces tear out what's left of a switchboard in order to start anew.*

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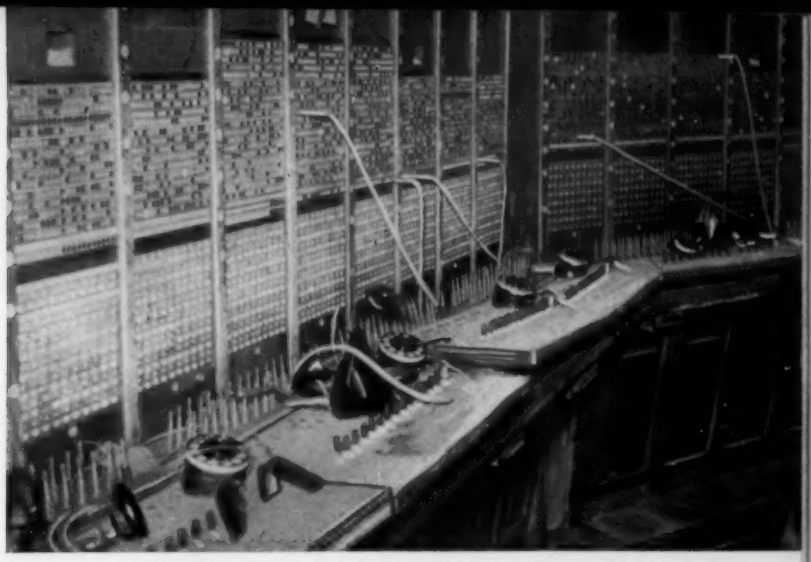

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*Casualty.*

*Night scene at the Western Electric Company's St. Louis distributing house as cross-arms are being pinned, braced and loaded into a waiting freight car.*

*This reel of cable, being loaded at the Hawthorne Works for the Indiana emergency zone, is one of a 5-car shipment of 169,300 linear feet of cable contained on 84 reels.*

*A general view of the wire shipping section in Western Electric's Point Breeze plant. The fully wrapped coils of wire in the background are being placed aboard a fast freight bound for a distributing house in the flood zone.*

when emergency generators maintained power where otherwise there was none and when water had to be brought in tanks because the regular supply had failed. So also can it be read in tales of ingenuity and quick thinking: of the central office kept in service with water deep on the frame-room floor because the main frame and test desk could be hauled up to the ceiling; of the town kept in touch with the outside world through magneto switchboards rushed to a nearby Long Lines repeater station when the local connecting company's central office went out of service for an indefinite period; of the vitally important link to a distant broadcasting station kept open by applying carrier current to the metallic lines at the upper and lower outside corners of a 4-cross-arm pole line, even though for 15 miles that line was under water. Most certainly the story can be told in terms of heroism, of devotion to duty far beyond the strict requirements of the job: of men risking their lives to install or repair or protect an important circuit; of other men working laboriously and without thought of self at whatever the emergency required; of men and women sticking to their posts while the same water which lapped higher each moment in the central office also engulfed their homes and their possessions; of women staying for days on days in telephone buildings without elevator power or even adequate water facilities so that they might handle the calls of Red Cross, government and other relief bodies, and all messages contributing to the alleviation of the situation.

In such terms as these can the story of the flood, and of the telephone men and women in the flood area, be told. But not here, not now. The canvas is too big, the scene too close at hand.

Out of the picture already stand, however, certain bold features. They represent the various arms of the Bell System as a whole mobilized to the assistance of the flooded territory.

Not only did plant crews from neighboring Associated Com-

panies respond to the need; Long Lines maintenance forces were rushed into the area, some of them from great distances, some equipped with boats and some others obtaining boats locally. Ahead of the flood they worked feverishly to protect the circuits into and through the river valley from the onward march of the waters. Where the waters rose, they were there to maintain the lines and to restore at the earliest feasible moment those which went out. To these men, and to their fellows on the localized battle grounds, is due the principal credit that few important points in the Ohio Valley were without telephone contact with the outside world for longer than brief intervals.

### The Wires Were Vital Links

Upon these long-haul circuits, during the early days of the flood, depended in great part the orderly organization of the nation's resources for rescue and relief work, and, indeed, accurate news regarding each community's needs. Outward long distance calls mounted rapidly. On Sunday, January 24, for example, the number of outward long distance calls from Cincinnati was 330 per cent above normal, from Louisville 184 per cent, and from Memphis 60 per cent above normal. The number of calls varied widely during the whole flood period, but a week later, on January 31, outward long distance calls from Cincinnati were still 84 per cent above normal, from Louisville 135 per cent, and from Memphis 70 per cent. Similar increases occurred in other cities, the effect of the flood crisis being reflected in marked traffic increases in such cities as Pittsburgh, Cleveland, Chicago and St. Louis.

To meet this sudden uprush of traffic, and to bring relief to operators who had been working at the switchboards under great pressure and trying conditions for many hours at a time, operators who volunteered for the service were sent from New York, Philadelphia, Cleveland, Detroit, Chicago, St. Louis, Kansas City, and Dallas to places where their help was most

needed, particularly Cincinnati, Louisville, and Memphis. Former operators in the flood area, realizing the emergency, also offered their services, and were accepted.

The Western Electric Company, source of emergency and replacement supplies and equipment for the Bell System, was already making large shipments into the sleet-stricken territory when first warning came of the flood catastrophe in the Ohio Valley. Throughout its widely distributed facilities east of the Rockies it set in motion its machinery for meeting major emergencies.

### The Supply Service Plays Its Important Part

Its principal factories and its distributing houses were placed on a 24-hour basis, ready to handle emergency shipments at any hour. Distribution and traffic specialists worked in day and night shifts, expediting shipments by train, plane, ship, and truck. The company's mobile crews of switchboard installers were placed at the disposal of the Associated Companies and some thousand men were held ready to join forces with other telephone men at an instant's notice.

With this plan of operation placed in effect virtually over night, emergency shipments commenced to speed toward the flood scene. Orders placed by the Distributing Houses and shipped by the factories or suppliers, almost without exception in a few hours after receipt, rapidly mounted to impressive totals. In just a little more than two weeks, these totals included thirty-five sections of No. 12 switchboards, 28,750 hand telephone sets, 23,700 subscriber sets, 38,610,000 conductor feet of rubber covered wire, 216,200,000 conductor feet of cable, 325,000 pounds of pole-line hardware. When the total extent of the damage is finally known and requirements ascertained, these totals will doubtless be greatly exceeded.

Contributing their share to the maintenance of service in the flood territory were power specialists from the Bell Telephone Laboratories and the American Telephone and Tele-

graph Company headquarters organization who went from New York to assist the operating companies in engineering and establishing emergency sources of current. In a number of instances, in both the large cities and in smaller communities, it was these emergency generators which saved the day and kept the service in operation when the normal supply of electric power had failed completely.

So in terms of the coördination and coöperation of the Bell System can this story of the Ohio River flood be told: of men and women coming to the aid of other men and women who were there in the thick of it; of the supply system and the men and women in back of that; of the scientists and the specialists and their resources of information and experience. Almost wholly in terms of men and women can and must the story of the telephone's victory over these unleashed waters be told. But these same men and women it is who form this country's nationwide telephone system. So the story can be told, too, in some part, in terms of the value of that organization, its heritage, its unity, its will to serve.

JUDSON S. BRADLEY

# The Telephone Business Office

THE telephone business office is provided to meet the needs of customers in arranging for new service, changes in service or the disconnection of service; securing information about bills or charges; or taking up any of the many questions that may arise between them and the Telephone Company. In other words, the business office is the customer's normal point of contact for direct dealings, in person, by telephone or by correspondence, concerning all phases of his business transactions with the Company.

Depending upon the community served and the varying requirements of small and large cities, business offices range from the small offices with one or two employees who handle all phases of customer transactions, up to the very large offices of 100 to 200 employees. In these larger offices one or more groups may specialize in handling all telephone and correspondence transactions together with the bulk of the record work associated with customers' service; another group may be engaged in handling solely the "public office" transactions (i.e., where customers visit the office in person); while separate groups also may take care of the preparation of service orders, the disposition of money received from customers in payment of bills, coin box collection work, etc. In the intermediate sized offices some of these functions frequently are combined to advantage under one group; for example, the office may be arranged so that the representatives handling telephone and correspondence transactions also may take care of the customers calling at the office in person.

There are more than 5,000 business offices of these varying sizes in the Bell System, with over 15,000 people engaged in work in these offices. Aside from the payment of bills, cus-

tomers initiate by personal visit to the office, by telephone call, or by correspondence nearly forty-two million transactions with the business offices each year. Impressions they secure in this way as to the efficiency and courtesy of the Company unquestionably contribute a great deal to their opinion of the Telephone Company.

## Improvement in Business Office Service a Continuous Activity

It is, therefore, highly important that there be an adequate number of conveniently located offices with suitable facilities and equipment and capable personnel well trained in a wide range of telephone matters.

Consideration of business office service and its improvement has involved, and will continue to involve, many related factors, such as the location of offices, building designs, interior layouts and arrangements, office equipment and appliances, selection and training of personnel for their duties, and adjustment of the force to handle the fluctuating volumes of customer transactions. Consequently, this work is under continuous study throughout the System. The headquarters staff of the American Telephone and Telegraph Company has worked with the Associated Companies in designing improvements, as well as assisting in their introduction and application. Rapid strides have been made during recent years in improving the layout and equipment of business offices, providing more of them and in improving all phases of their operation.

To the customer who prefers to transact his business with the Company by telephone or correspondence, these improvements are apparent to him only by the more prompt, accurate and efficient handling of his business and by the pleasing manner of the business office representative.

For the customer who wishes to call personally at the business office, however, the greater ease, convenience and physical comfort with which he may transact his business in this manner

has been particularly apparent and pleasing. The progress during recent years in improving this phase of business office service, as described more fully in the remainder of this article, is illustrative of the improvement which has been made in business office operations as a whole.

## Meeting the "Public Office" Requirements of Customers

Of the nearly forty-two million transactions which customers initiate with the business office each year, about twelve million, or 30 per cent, are by personal visit to the public offices. In addition, a fairly sizeable portion of the customers prefer to pay their monthly bills by coming to the nearest available public office. While one public office in each of the smaller cities usually is sufficient to meet the customers' convenience in these respects, in the larger cities or metropolitan areas, several such offices may be required. Adequate coverage from the customers' standpoint involves consideration of such factors as geographical conditions, community of interest, and the availability of reliable transportation facilities. In addition, growth of the community, changes in transportation facilities, etc., frequently lead to changes in location or the establishment of additional public offices. As an illustration of the attention given this matter of conveniently located public offices during the last ten years, in the 72 cities in which over half the customers of the Bell System are located, the number of such offices has been increased 77 per cent, to meet the changing requirements of customers due to growth and other related factors.

## Improvements in "Public Office" Arrangements and Facilities

A few years ago, most of the public offices in the larger cities were of the conventional "counter" type, as shown by Figure 1,

although in some offices turrets or screens were built into the counters to segregate the positions at which representatives were located, as shown by Figure 2. Customers stood at the counter while transacting their business with the representatives or while waiting for attention during busy periods. Early in 1926, however, the New York Telephone Company introduced an experimental public office in Brooklyn where the counter was eliminated entirely, with the exception of that part devoted to receiving payments, and each public office representative equipped with a desk at which a customer could be comfortably seated while transacting his business. The advantages of this type of office over the "counter" type became quickly apparent and a number of offices in the New York Company and other Associated Companies were similarly equipped. Experience indicated that, in order to assure quiet working conditions, it was desirable to construct partitions in the larger offices so as to segregate the public office from the remainder of the business office, where the two were at the same location.

Pictures of two so-called "counterless" public offices are shown in Figures 3 and 4. These particular offices are designed to handle only those transactions with customers who visit the office in person, telephone and correspondence transactions being handled by an entirely separate force. Also shown in Figures 5 and 6, however, are pictures of the counterless arrangement subsequently introduced in the so-called combined office; that is, where the same representatives handle all transactions with customers whether they are by personal visit, telephone or correspondence. It will be noted that these offices are not materially different in appearance from the purely public offices, since they also are designed to permit customers being seated at a representative's desk during the interview.

Where necessary, the manager, or a representative acting as a floor director, arranges for customers to be waited upon

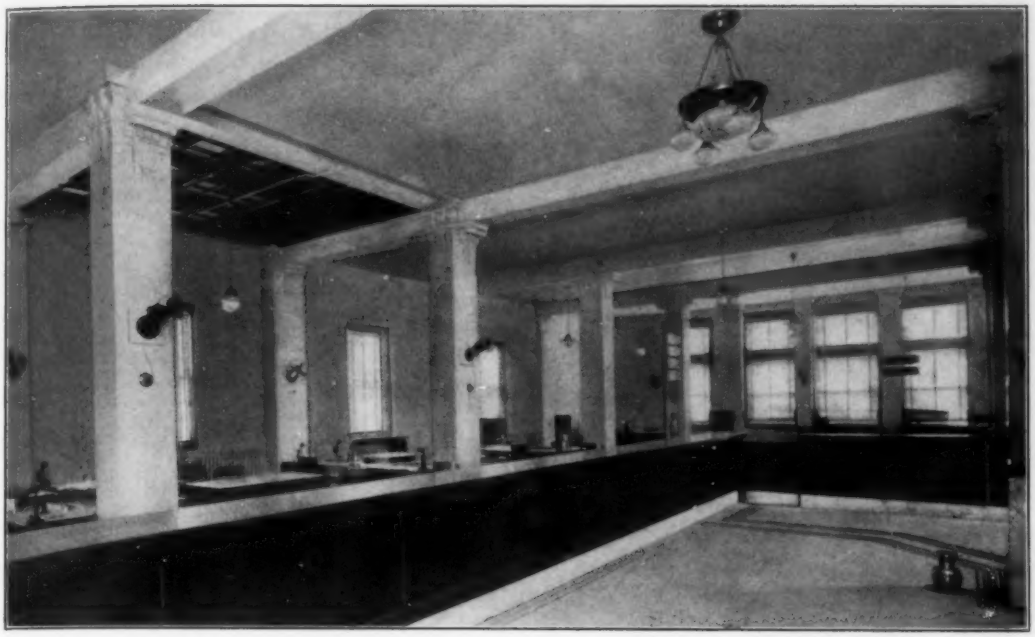

FIG. 1. A TYPICAL "COUNTER" TYPE PUBLIC OFFICE.

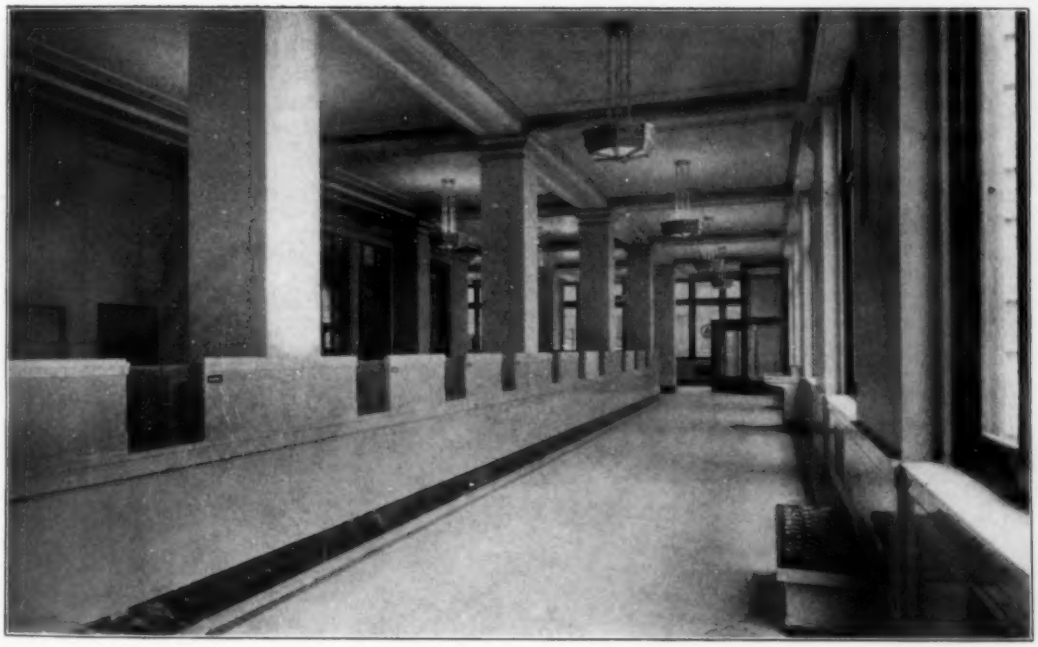

FIG. 2. A "COUNTER" TYPE PUBLIC OFFICE, SHOWING THE TURRET CONSTRUCTION AND POSITIONS AT WHICH REPRESENTATIVES ARE LOCATED.

FIG. 3. A PUBLIC OFFICE, WHERE CUSTOMERS TRANSACTING THEIR TELEPHONE BUSINESS IN PERSON MAY BE SEATED IN COMFORTABLE CHAIRS DURING THE INTERVIEW. ONLY PERSONAL VISIT TRANSACTIONS ARE HANDLED IN THIS OFFICE.

FIG. 4. A PUBLIC OFFICE, SIMILAR TO THAT SHOWN IN FIGURE 3 BUT DIFFERING SLIGHTLY WITH RESPECT TO ARCHITECTURAL DETAILS.

FIG. 5. A BUSINESS OFFICE OF THE COMBINED TYPE. PERSONAL VISIT, TELEPHONE AND CORRESPONDENCE TRANSACTIONS ARE HANDLED BY THE SAME REPRESENTATIVES, THE NECESSARY OFFICE RECORDS BEING FILED IN SPECIALLY DESIGNED DESK DRAWERS. THIS ARRANGEMENT IS CONFINED MOSTLY TO OFFICES IN THE SMALLER CITIES.

FIG. 6. A BUSINESS OFFICE, SIMILAR TO THAT SHOWN IN FIGURE 5 BUT DIFFERING SLIGHTLY WITH RESPECT TO ARCHITECTURAL DETAILS.

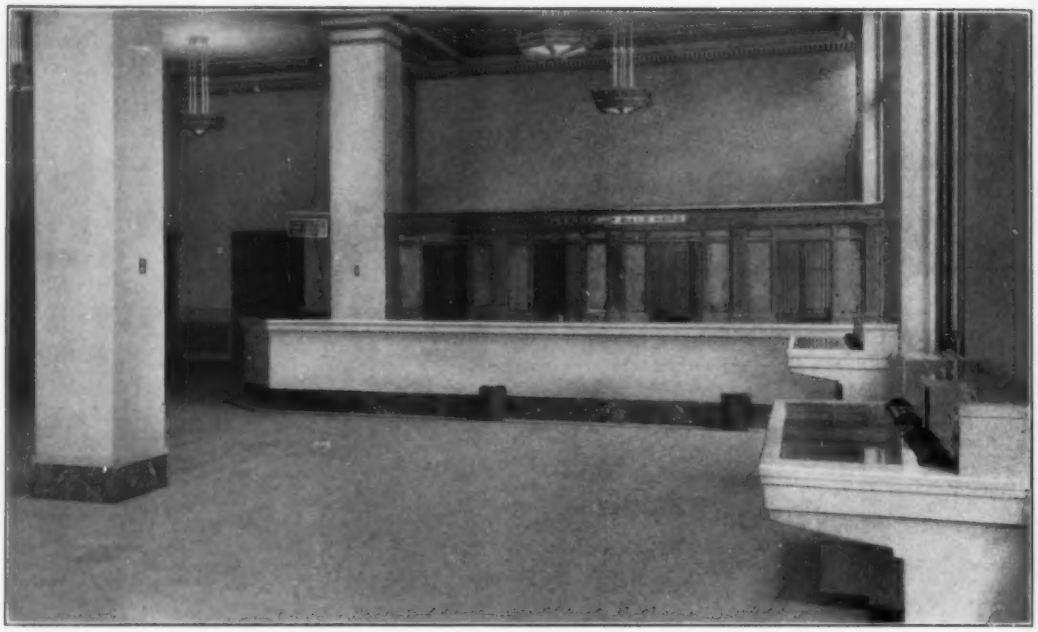

FIG. 7. PAYMENT COUNTER WITH GRILLE WORK ENCLOSING TELLERS' POSITIONS. THIS COUNTER WAS REMODELED, AS SHOWN IN FIGURE 8, AT THE TIME OF CONVERTING THE OFFICE TO THE COUNTERLESS ARRANGEMENT.

FIG. 8. OPEN TYPE PAYMENT COUNTER USED IN COUNTERLESS OFFICES. THIS IS THE REMODELED COUNTER, SHOWN IN FIGURE 7, AFTER CONVERSION OF THE OFFICE TO THE COUNTERLESS ARRANGEMENT.

FIG. 9. EQUIPMENT DISPLAY LOCATED IN THE PUBLIC OFFICE ADJACENT TO THE WAITING SPACE.

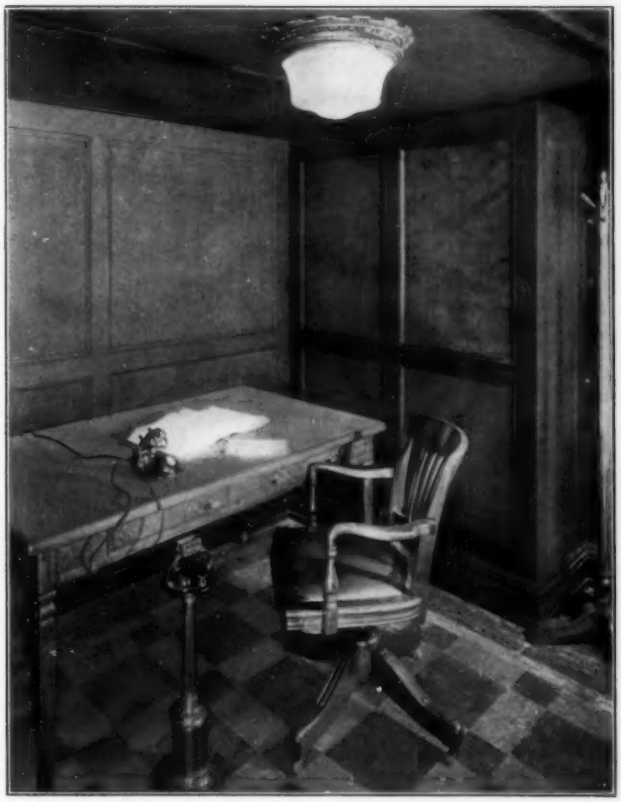

FIG. 10. INTERIOR OF A "CUSTOMER'S ROOM," WHICH HAS A DIRECT ENTRANCE FROM THE PUBLIC OFFICE.

FIG. 11. PUBLIC TELEPHONE AND DIRECTORY FACILITIES IN A PUBLIC OFFICE, LOCATED ADJACENT TO THE WAITING SPACE.

FIG. 12. DISPLAY WINDOWS, SHOWING USE FOR INFORMATIONAL AND PROMOTIONAL PURPOSES.

FIGS. 13 AND 14. SMALL COUNTERLESS BUSINESS OFFICES, SHOWING DESKS EQUIPPED FOR RECEIVING PAYMENTS.

FIGS. 15 AND 16. SMALL COUNTERLESS BUSINESS OFFICES, SHOWING DESKS EQUIPPED FOR RECEIVING PAYMENTS.

and escorts them to the proper desk. Comfortable chairs, settees or davenports usually are provided for the use of customers who may be required to wait for a few minutes when all the desks occasionally are being utilized, and for the convenience of those persons who are merely accompanying a customer. In many cases, of course, simple inquiries by customers may be answered courteously and quickly by the manager or floor director when greeting the customer, thereby speeding up the handling of customers' business in such cases.

One of the principal advantages of the counterless arrangement, of course, is that it permits customers to be seated during the interview. This is particularly appreciated by elderly persons or those having physical infirmities. There are, however, many other important advantages. Discussions between the customer and the representative are not readily overheard by other customers, since ample space is left between desks, thereby encouraging private conversations which customers so frequently desire when discussing their individual telephone business. The physical strain on representatives who might otherwise be required to stand throughout the greater portion of the day is reduced and their prestige is enhanced in the customers' minds by being seated at desks instead of standing behind a counter. The entire atmosphere of the office is quietly businesslike, and the comfortable arrangements tend to encourage courtesy and patience on the part of both customer and representative, which frequently facilitate the work of securing the facts concerning a difficult or complicated situation and arriving at a mutually satisfactory agreement as to the action to be taken. In addition, the establishment of a new business office with the counterless arrangement requires less capital investment, since it eliminates a major item of expense, the construction of a suitable counter.

With the counterless arrangement other improvements in the design, arrangement and furnishings of the public office also

were introduced. For example, the old type metal cages and grille work enclosing the payment counter were obviously out of place in the setting which resulted from removing the rest of the counter and providing attractive desks, chairs and other facilities. As a means of further assisting in furnishing a pleasing and personal service, as well as improving the general appearance of the offices, an open type payment counter was developed which does not require metal cages or grille work. The pictures in Figures 7 and 8, which are of the same counter before and after conversion of the office to the counterless arrangement, show the radical differences in appearance of these two types of payment counters. The open type counter is designed to permit tellers while seated to receive and pass money over the counter with ease and to converse freely with the customer without the obstacle of a grille or screen in between. At the same time, the counter on the teller's side is designed to provide adequate protection of money, and on the customers' side such features as a shelf on which customers may place small packages when making payments and openings in the face of the counter for disposing of envelopes and other waste paper frequently are provided. The payment counter in a public office is always located near the entrance, or between the entrances if there is more than one, so that it may be easily seen and reached by customers.

A great deal of study has been given to the design and arrangement of these new type offices as a whole, to the end that the improvements may be in keeping with the stability, dignity and character of the business. It was found practicable to provide attractive and convenient offices appropriate to the locality they serve, without involving or even giving the impression of extravagance, and in many cases this was accomplished at less cost than would have been incurred with the counter arrangement. Based on the experience of the Companies, considerable information with respect to the selection

and planning of business offices was accumulated, which is now in use throughout the System. Among the features being given consideration in the planning of new public offices in addition to those mentioned previously, are (1) the provision of appropriate equipment displays, consisting of the simpler types of services which may be demonstrated readily to customers, located near the entrance or adjacent to the waiting section, as illustrated in Figure 9; (2) "Customers' rooms" with a direct entrance from the public office, where customers desiring to place a large number of local or long distance calls may do so with privacy and comfort, as shown in Figure 10; (3) adequate public telephone and directory facilities located where they may be seen readily and used without disturbing other customers, a typical arrangement of which is shown in Figure 11; and (4) display windows for use of informational and promotional displays, such as shown in Figure 12.

### Extent of Introduction of Counterless Offices

The counterless arrangement for public offices was extended gradually to offices of varying sizes and was found to be adaptable readily to large or small office conditions. While new offices may be established at less expense with the counterless arrangement, as compared with the counter plan, and small counter offices readily converted to this arrangement, in many of the larger counter offices the "out-of-pocket" conversion expense is such that, in general, conversions of these offices have been confined to cases where major changes, additions, or moves were needed for other reasons. Nevertheless, during the last ten years a considerable proportion of the larger offices have been converted to the counterless arrangement, as shown by the chart in Figure 17, and conversion of most of the remaining offices in this group is planned coincident with other contemplated changes. There are relatively few in the large group of offices serving communities with less than 1,000 telephones, which are not now on the counterless basis. In these

smaller offices, where all of the business office work may be handled by one or two representatives, the payment counter also has been eliminated in many instances by remodeling one desk to facilitate receiving payments, a transaction requiring so little time that customers usually do not prefer to sit down. Figures 13, 14, 15 and 16 illustrate the arrangement now

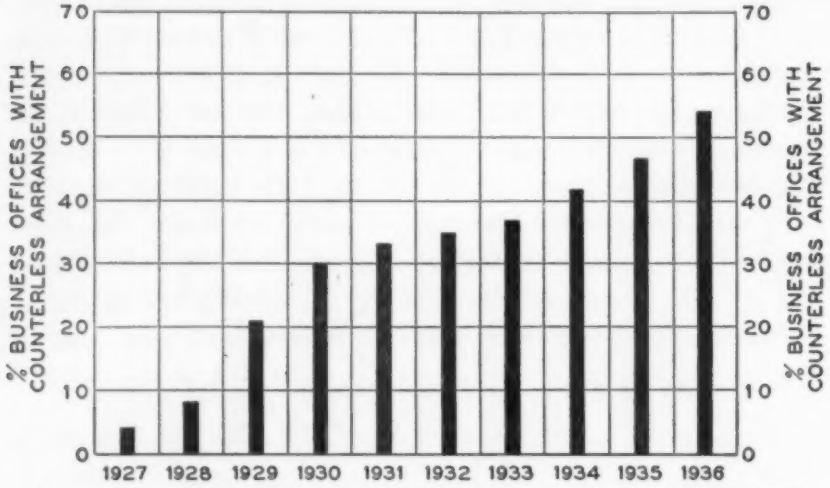


FIG. 17. BELL SYSTEM COUNTERLESS OFFICES IN CITIES HAVING 1000 OR MORE TELEPHONES.

widely in use in small counterless offices requiring only a few representatives.

While it is desirable to locate a public office in that section of the area served which is most convenient to the largest number of customers, in most cities it has not been found necessary to have quarters in the busiest portion of the principal business district. Frequently Company-owned buildings, either administration or central office buildings, may be located sufficiently close to a focal point in the community to permit including a public office, or a complete business office, on the ground floor. A number of additional public offices of the counterless type have been located in such buildings in the larger cities during the last few years.

R. P. JUDY

# Language and the Telephone Art

NEXT to man himself—the how and why of his living, moving and being—probably the most interesting thing in the world is the speech of man.

Sounds becoming words; words expressing thoughts; thoughts stimulating actions; actions translated into history. Words,—the media through which man makes known his aspirations and his fears; through which are recorded the experience of the past so that the race, generation by generation, may improve; speech—one of the characteristics which makes man the highest animal. Can anything be more significant than words?

Where do they come from? What causes them to be born? How do they creep into the living tongue? What gropings for knowledge, what accomplishments, what hardships, obscured by mists of the past, lie behind words in daily use?

*Forsythia* is not merely an arbitrary term, designating a yellow, spring-flowering shrub, so well known to all of us that many think it native to our continent. It is, at the same time, a memorial to William Forsyth, British horticulturist, who discovered the species in the wilds of China. *Macadam* is a monument to the inventor of a road surfacing process, as well as a common name for the process, itself. *Volt* is a measure of electrical intensity, but it is, likewise, a tribute to Volta, the physicist.

Back of words like *volt* and *ohm* and *ampere* stand shades of scientists, great ghosts that whisper (if we but pause to listen) of man's eternal struggle with the unknown and of the success which sometimes crowns the effort of gifted individuals. There is in such words acknowledgment of a debt to the past and encouragement for the future.

Consider, for a moment, a name (it is both noun and verb) so common to American speech that it is doubtful that a day

passes without some reference to it by half, or more, of the population of the United States. That word is *telephone*. It derives from two Greek words: one, meaning "afar"; the other, "voice" or "sound."

In the American Telephone Historical Library at 195 Broadway there is on file a letter which Alexander Graham Bell wrote to an unnamed correspondent on April 9, 1888. It begins as follows:

> *Dear Sir:*
>
> Your note of the 7th inst. just received. It will give me much pleasure to be of assistance in discovering "the father and the birthday of the word 'Telephone.' . . ."

The inventor refers, then, to a number of sources, contributing to a justification of the word. He mentions "the Telephonium or music telegraph of M. Sudre" and describes it as "a trumpet or bugle that could be heard three miles whereby 'musical speech' could be produced, depending on the combination of the seven notes—Re, Mi, Fa, etc." He quotes Dr. Romershausen, the author of "The Telephone, an Acoustic Means of Communication" as proposing in 1838 "a means of speech communication . . . through the use of far-reaching transmission of sound in narrow tubes." He takes notice of the glorified speaking tubes proposed by a clergyman named Gautier and an Englishman named Dick. And of Reis' instrument, which Bell contended, incidentally, would transmit pitch only and not other qualities and was, therefore, incapable of transmitting genuine speech, he wrote:

> I need hardly refer to the use of the word "Telephone" by Reis and others about 1860 to designate an apparatus for transmitting musical pitch—and specially the pitch of the human voice.

Nor did he omit Elisha Gray's use of the word. He wrote:

> . . . about that time (1877) an apparatus composed of tuning forks and resonators was exhibited in this country by Mr. Elisha

> Gray of Chicago as a " telephone." We were both lecturing on the " telephone " at the same time. He lectured upon the " telephone " alone—while mine were lectures on " The Electric Speaking Telephone."

Bell cited a passage from a letter he had written to Gray, dated March 2, 1877, which was used as evidence in certain Bell patent cases, as follows:

> I have not generally alluded to your name in connection with the invention of the electric " telephone " for we seem to attach different significancies to the word. I apply the term only to an apparatus for transmitting the voice (which makes it strictly in accordance with the derivation of the word) whereas you seem to use the term as expressive of any apparatus for the transmission of *musical* tones by the electrical current.

With a discussion of transmission of sounds over wooden rods, threads, the " lovers' telegraph " and other means, Bell's letter closed.

One sentence, appearing early in the communication, was this: " I christened my apparatus ' The Electric Speaking Telephone ' but the world has abbreviated it to ' Telephone ' alone."

In the light of events, the statement has weight. For the word *telephone,* in modern usage, compresses within its three syllables the whole history of the development of voice communication from Dr. Bell's basic patent to the coaxial cable.

Not long ago, listening to a radio program featuring the competitive offerings of amateur performers, I heard the announcement that the winning amateur could not be determined until judges had read the *decibels* measuring the volume of the audience's applause. That very day I had written, in an article not for publication in a telephone periodical but for consumption by the general public—" To a man, the busy hum of a tea-party is so much sound and fury, measurable in decibels." I was, as it were, an eye-witness to the introduction to living language of a term created by telephony.

All of us are aware that from foreign countries, from the

lower strata of society, from the arts, picturesque terms emerge, bubble for a while in the cauldron of slang, and eventually take their places—many of them—as respected members of our linguistic community. Thus, British army men brought back from India the word *pukka,* meaning "thoroughgoing" or "complete." A *pukka* officer is, for example, an officer and a gentleman, virtually above criticism. From Africa the troops brought us *trek,* a march. The underworld has given us *gunman* and *racketeer.* The painter contributes *highlight* in the sense of accent, while the new wave of swing music is producing an avalanche of strange phrases, at present meaningless gibberish to the average man, but perhaps destined in time to enliven his vocabulary.

### The Laboratories' Contribution to the Language

The laboratory, too, does its share in giving variety to everyday speech. *PBX,* due, no doubt, to the public contact with Private Branch Exchange operators, is gaining a foothold. *Sidetone,* though defined by engineers as "reproduction by the telephone receiver of a telephone set of sounds actuating the telephone transmitter of the same telephone set" is, in the sense of a continuous, irrevelant sound, coming into common talk. *Microphone,* or, oftener, "the mike" (to engineers, a synonym for "telephone transmitter") is, by way of radio and talking motion pictures, a part of everyman's verbal equipment. And now *decibel* is, more and more, being employed by the man in the street as meaning a unit measure of sound volume.

To engineers, *decibel* does not mean quite that. It is an international word, a synonym for the obsolete term "transmission unit," and is abbreviated, officially, "db." It is one-tenth (deci) of a "bel." The last syllable derives from Bell, the inventor of the telephone, just as another unit, of the same nature as decibel but differing from it in magnitude and quite

unknown as yet in ordinary speech—the "neper"—stems from Napier, the inventor of natural logarithms.

All right, the average man says, a decibel is a tenth of a bel. So what is a bel? And the engineer replies: "A bel is the unit of measure of the ratio of two amounts of power, the number of bels corresponding to any given ratio of two amounts of power being the logarithm, to the base 10, of this ratio." And he might add, "The practical unit is the decibel."

### An Engineer Defines the Decibel

But, if the engineer happened to have a soft spot in his heart for the layman, he might say, as John Mills does, in his "A Fugue in Cycles and Bels," "The 'decibel' scale of the communication engineer is now generally accepted. By its use comparisons may be conveniently expressed; acoustic power, or its electrical equivalent while in process of transmission, may be referred to some standard and quantitatively described as so many units above or below the standard.

"The unit is the 'bel,' named after the inventor of the telephone—but its submultiple, the euphonious 'decibel,' abbreviated 'db,' is much more commonly used. It does not stand for any definite amount of power but rather for a specific percentage increment.

"Imagine that one listens alternately to two musical notes identical in pitch and for the moment of equal intensity. Then one of the sounds is slightly increased and the comparison repeated; and so on, until to the ear the notes appear to differ in loudness. The minimum perceptible difference in intensity is thus determined for the conditions of the experiment, that is, for a definite pitch of note and a definite initial sensation.

"Repeat the experiment, keeping the stronger of the two tones steady and increasing the intensity of the other until it is just perceptibly louder. Another level of sensation is thus attained. Successive sensations, it will be found, arise from amounts of acoustic power which form an increasing series like

the value of a bank account in compound interest. The average increase in acoustic power which the ear can detect is about twenty-five per cent. On that basis each level corresponds to a power 1.25 times that of the next lower level. Each level in the series represents a step of one decibel. (A bank account which increases at that rate of twenty-five per cent would double on the third interest date and be ten times its original value on the tenth.) Each level in this series of acoustic power represents a step of one decibel; ten steps and one has a power level ten times that from which he started, a whole bel higher.

"Applying this scale, for describing acoustic power, to speech engineers have found that very loud speech is about twenty decibels higher than speech is on the average, and very faint speech about twenty decibels below average. Ordinarily then speech covers a power range of forty decibels. Since for every ten decibels power increases ten times, this range represents an increase of ten thousand times. When one argues his acoustic power is probably, therefore, about ten thousand times greater than it need be."

## Telephony Is a Borrower of Words

The situation of the telephone engineer with respect to his terminology differs somewhat from that of the biologist or the medical man. The latter, following academic tradition, derives words, when need for a new one arises, from Greek or Latin or, perhaps, from the physician most closely associated with the study of a specific irregularity. Thus, a type of paralysis is called *Parkinson's Disease;* or, the capacity of living tissue to recover from injury is described in medicine as *vis medicatrix naturae.*

It is true, of course, that some telephone words, such as *microphone,* stem from ancient tongues. By and large, however, the communication vocabulary—due in the main to the development of the industry by practical rather than cloistered men—has been built up by borrowing from other arts and

crafts. The telephone *plug* took its name from a similar device used in telegraphy. The hole in the switchboard into which a plug fits is called a *jack* (it was first known as a jack-knife switch) because its movable parts resemble an old-fashioned Barlow. When voice currents were stepped up as they passed through an intermediate telephone office, the amplifying devices were termed *repeaters,* after a set of repeating relays in telegraphy, though no one can, to be sure, hear a telephone repeater repeating conversation.

### Initials Sometimes Form Names

Ultimately, telephony reached a point at which prior arts failed to supply terms. Some of the descriptive phrases thus evolved were cumbersome. In the early days of transoceanic telephony, for example, a good many cabled references had to be made to the *voice operated device anti-singing*. Obviously, this had to be contracted. It was called by its initials—*vodas,* and it is so known to-day. If you hear a telephone engineer mention vodas, he will be referring to a little black box in a transoceanic circuit, which clears an electrical pathway ahead of a speaker's voice and at the same time blocks a return path to his ear. Were this not done, serious interference between various parts of the two-way transmission system would result.

One of the problems of transoceanic radio telephony—the necessity of sending out as much radio power as possible to override static—has brought the word *vogad* into our vocabulary. This *voice operated gain adjusting device* operates on the speech coming into the control office to iron out the differences between loud voices and weak ones. When a loud talker begins, the vogad quickly adjusts the circuits so as to reduce the volume, if necessary, to a point where the radio transmitter is fully loaded and no more. If the next talker should be a weak one, the vogad will increase the volume until the full-load point is reached.

In any speaker's voice, be it loud or weak, there is a range

of 1,000 to 1 between the loudest and the faintest sounds. If the fainter sounds could be amplified, they would override the static better, and if the louder sounds were not amplified, the radio transmitter would not be overloaded. A device which does this is called the *compandor,* because it *com*presses the range at the transmitter to be only 30 to 1, and ex*pands* it at the receiver to be the full 1,000 to 1 again. When static is heavy, this device often makes usable a radio channel which otherwise would be too noisy.

A more euphonious group of telephone words are those formed by joining syllables which suggest properties of the material itself. The famous *permalloy* is an *alloy* of iron and nickel whose *perm*eability to magnetism is very high. Its younger sister *perminvar* is an alloy whose *perm*eability is nearly *invar*iable with changes of magnetism. A *varistor* is a device, for example a copper oxide rectifier, whose res*ist*ance *var*ies with the applied voltage.

Just as *decibel* is creeping into the talk of the man on the street, so we may expect to meet at some time in the future *vodas* and *permalloy* and *varistor.*

Engineers are not especially happy over this transmutation. Sticklers for accuracy (as they should be, of course), they object to the distorted meaning, which almost invariably is applied by the average user of a word lifted from technicians. The process cannot be avoided, however. It should, indeed, be recognized not alone as a means by which common speech is enriched, but as unconscious tribute paid to technical skill which makes possible the steady forward march of the telephone art.

STERLING PATTERSON

# Science Research in Electrical Communication

EXCERPTS FROM AN ADDRESS BEFORE THE BOND CLUB OF NEW YORK, FEBRUARY 19, 1937, BY DR. FRANK B. JEWETT, VICE-PRESIDENT, AMERICAN TELEPHONE & TELEGRAPH COMPANY; PRESIDENT, BELL TELEPHONE LABORATORIES, INC.

DURING the past thirty years, and most actively within the period of twenty years, we have been living in an age in which there has been an increasingly vast stream of new knowledge coming into the world. Primarily, it comes, of course, from the fundamental research laboratories of our great institutions of learning. Much, if not all, of that new stream of knowledge is potentially applicable to practical things, and the fact that it is a large stream and an ever increasing stream is becoming more and more obvious and more and more utilized by so-called "practical people."

The recognition accorded the industrial research organizations associated with businesses which are grounded on science has been growing, both in numbers, in size, and in efficiency. From my thirty years in an industrial organization with practically the whole of that time on the research phase, and incidentally, in contact with much research in fields quite outside of communication, it seems to me that in many kinds of activity, industrial research is probably the most important thing that a business can concern itself with if it has regard for its future well-being and its future safety.

If one looks back over industrial history one finds the gravestones which indicate the dangers of not possessing a forward-looking knowledge and utilization of the things which are potentially available in the field of science.

If you want examples of how dangerous it is to assume fixation for a present situation either for a nation, a vast in-

dustry or even a part of an industry, you can pick out almost any number for your illustrations. I will give you three that come to mind. The first affects the integrity of a nation's economy: the situation in Chile, where you had a whole national economy, based in the last analysis on the sanctity of one raw material, sodium nitrate. The world's supply of fixed nitrogen was largely dependent upon the Chilean supply, and the whole economy of the nation was based on the income from the exploitation of that natural resource. But out of science has come, in the last two decades, means for producing fixed nitrogen, artificially, which destroyed or largely destroyed the basis of that economy.

Take another case where an industry grew out of science—take our electric street railroads, our interurban roads, which twenty-five or thirty years ago were looked upon as more or less fixed instruments in our domestic civilization. Also out of science from which they sprang came the internal combustion engine, which in its application to the automobile has resulted in the complete or almost complete destruction of the interurban railways.

Or take another case, one in the amusement field, the silent motion picture, where with the coming in from the outside of another adaptation of science the whole industry had to be shifted over from the silent operation to sound.

So whether it is for the internal protection of an industry which wants to advance in its own field or for its protection against the incursion of something from the outside, in the last analysis if that industry is based on an application of science, it behooves the industry to look keenly to its interest in organized scientific research.

In addition to these factors, which are present in any industry grounded in the application of science, there is another factor which results from the operation of the patent law which creates in many industries a very strong urge not only to conduct scientific research but likewise to cover the results of this

research with patents. Contrary to what I think is the common belief, patents issued by the Government on inventions do not convey an exclusive right to the patentee to do the thing described. The right to do things not otherwise prohibited is assumed to be a right common to all. What a valid patent does do is to give to the patentee the right to exclude others from employing the things covered by the patent, except as he may give permission either by license, sale or otherwise. This is a property right which the patentee cannot be forced against his will to extend to others. In such a situation there are only two things which a desiring purchaser has available; one is money, which may be useless if the patentee has no desire whatever to sell for money, or if his money price is exorbitant. The other thing is patents of a character which the patentee himself may desire and need in the operation of his affairs. As this situation often exists it becomes important to have patents for trading with or without money consideration.

The spread of applied science with consequent increasing number of patents of increasingly wide applicability has created an increasing number of situations in which both parties holding patents must have rights under the other's patents in order to operate. From this standpoint alone there is every reason why industries grounded in science should seek to conduct industrial research as the cheapest and most certain way of insuring freedom to operate and expand.

## The Importance of Research in Industry

I have often thought that if I were interested in a large way in the financial aspects of industries involved in applications of science and whose future I wished to guard, I would be very much more concerned with finding out what the attitude of management was toward organized scientific research in their own field, and the way in which they carried it out, than I would in any other aspect of the business. No amount of good organization, no strength of financial structure, no amount

of good salesmanship can counteract the destructive effects of something which may spring almost overnight out of some new discovery in science, or the application of old knowledge by people quite outside of one's own business. Both as regards internal growth and external protection, we have had enough proof in the last twenty or thirty years to show us that applied science research is one of the essential things in many modern businesses if they wish to live and prosper.

In a well organized industrial research establishment—and by well organized I mean one in which the quality of the men engaged in it and the way in which they are associated together is effective—findings are practically devoid of the possibility of major catastrophes. This is because the final conclusions of a train of research undertakings are the end result of a process made up of an infinitude of small mistakes, each corrected as it arises, and no one of which is vital. When therefore the stage of practical application has been reached substantially all possible technical difficulties have been unearthed and taken into account. One can then proceed with a high degree of assurance.

It is not, however, safe to stop at this point since otherwise the time may come when one's activities may be subjected to a danger from the outside. Hence one must also progress with investigation of allied arts as well as his own.

Now in all industrial research, in whatever field, there is a common factor. The productive strength of any research organization is the trained understanding of human beings associated together for teamwork and applying the scientific method in which preconceived ideas are tested experimentally, under controlled conditions, with the implements and techniques of an established proven art.

As to his ability to carry on effective work, it makes very little difference in what field of science a man has obtained his training in the fundamentals of the scientific method. It may mean of course that Bill Jones, who obtained his training in

the field of physics and finds himself injected into problems in the field of the chemical sciences, is at a slight disadvantage to Sam Smith who obtained the same fundamental training in chemistry. It is, however, only a temporary disadvantage which obtains only until Bill has acquainted himself with certain facts. Initially he must work a little harder to get his facts but the scientific methods and techniques with which he has become acquainted are applicable in all branches of scientific investigation.

An illustration from my own field comes to mind. Under the operation of our age retirement rule we recently retired a man who has probably produced more of outstanding value in the communication field than any other man now living. His productions were in the field of abstruse mathematical physical science but his training was that of a civil engineer. However, it was a good training and when he found himself injected into a strange field he was not lost because all he had to do to become a producer was to learn certain fundamental facts in that field and apply to them the methods he had already learned.

## The Field of Research in Electrical Communication

Now to get on to the field in which I am particularly interested—electrical communication. This field of electrical communication is characterized by something which is rather unique in the whole field of industrial research. While we deal enormously with physical things, our objective in the last analysis is not primarily an interest in physical things per se. Substantially we sell nothing of a physical character. Practically every other industrial research organization I am acquainted with is engaged in creating physical things to be sold to the ultimate consumer.

In our business the thing which we sell is the most intangible thing in the world. Our vendible product is merely an ability to give to men the facility for transmitting their thoughts from one place to another. Substantially all of our work in con-

nection with physical things is designed to give us a better, more extensive, cheaper and so a more desirable facility.

We are, moreover, necessarily dealing at all times with an intricate past as well as a future. Everything which we do and everything which we put into use must not only be good in itself and attain its individual objective, but it cannot be used at all, no matter how good it may be inherently, if its injection into an already complex existing entity will destroy a part of what we have already accomplished.

In other words, if, for example, we design a peculiar form of telephone equipment for the city of Portland, Maine, it cannot be employed, no matter how well it may be adapted to some peculiar local situation there, if its introduction will destroy or impair the ability of the people of Portland to talk, say, with people in New York. This necessity arises from the fact that electrical communication, and particularly telephony, involves an enormous complex interrelated functioning of material things, no one of which can be altered without danger of dislocating somewhat the functioning of something else at a distant point.

The job which we industrial research people do may appear complicated to an outsider not trained as a scientist. Like all intricate things, it is complicated in a way but in another way it is a definitely straightforward kind of a job, and this for a very simple reason. I have mentioned that effective research organizations have to be equipped with properly trained, properly qualified human beings. The problems with which they deal, however, since they concern inanimate things, are not such as to involve many of the things concerned with human emotions and reactions which complicate our undertakings in many other activities. In a word, we industrial research people do not have to concern ourselves largely with human behavior reactions. In any particular investigation, whether we know it or not, the yardstick by which our undertaking will finally be judged is the yardstick of absolute truth.

Old Dame Nature sets the yardsticks and no amount of mental gymnastics or wishful thinking on our part can alter them. Whether we do a good or a bad job is therefore dependent very largely on our ability and upon our knowledge of the invariable factors which Nature puts up.

Coming now to telephony, the ultimate is a system which would enable any one anywhere, at any time he might elect, to be put in instantaneous perfect communication with anybody anywhere else in the world. This is the ideal toward which we have always striven but which in all probability we will never quite reach.

## Telephony's Three Major Fields of Research

Now this ideal telephone service involves three major fields which interest us on the physical side and within which, broadly speaking, all of our problems lie. First, at the sending end, there are the instrumentalities which translate speech waves in air into those electrical impulses which we use to carry the message of the intangible thing called "thought," to some distant point, at which point there are other instrumentalities which reconvert the electrical impulses into sound waves that are substantially replicas of those issuing from the speaker's mouth. In other words, the instrumentalities of this first category are represented by the familiar telephone transmitter and receiver which you have on your desk, and the apparatus immediately associated with them. Second, there are the channels over which the electrical impulses are carried from one place to another. These channels must be efficient not only from an energy standpoint but also they must transmit that energy from one point to another without sufficient modification of form to impair intelligibility. It would be of no value to me as a telephone engineer to devise a telephone channel from here to San Francisco so efficient that it would deliver all of the originating energy or even many times that amount if the energy reached San Francisco in such a form as to prevent

the production of intelligible speech. Thus in this second category we have a dual problem. On the one hand we have the same sort of problem with which power engineers have to deal, namely, one of energy efficiency, and in addition we have an intricate problem of so transmitting the energy that we do not substantially impair the intricate and rapidly varying form in which speech delivers it to us.

The third problem pertains to the means of interconnecting these channels of transmission quickly and economically to provide for the random demands of those who wish to use the telephone. At one minute you or I may wish to telephone to a man in the adjoining block and a few moments afterwards from the self-same instrument we may wish to talk to a man in London or in San Francisco. Ability to do these things to the satisfaction of our customers is dependent on our ability to switch and interconnect channels of communication with great rapidity.

These are our three major fields of interest, and I am now going to attempt to illustrate a very few of the problems with which we have to deal and the distance to which we have gone in their solution.

Time will not permit consideration of all the fields and consequently I will not bother you with anything concerned with the first category, that is, the apparatus on your desk, although the problems concerned with it are at the very heart of all we do. Let us take up, rather, the case of switching mechanism, after which, if time permits, I will go a bit farther and tell you something about the field which is most spectacular and in some ways most interesting, namely, the channels of communication.

Originally, in the earliest commercial adaptations of telephony, when the art was simple and embryonic, switching was invariably done by a piece of human apparatus—the telephone operator. To a large extent it is still done in this way. Initially and where it is still used this human switch was and is effective, despite certain obvious limitations. In some situa-

tions it is doubtful whether there can ever be any other form of switching mechanism.

As a human relay or switch the operator receives spoken orders which indicate to her that two particular channels of communication are to be connected together, and then with her hands she connects these channels together by means of flexible cords or otherwise. Originally that was all there was to the switching operation, but as telephony grew, as the number of subscribers to be taken care of increased and as the number of channels between switching centers increased, the limitations of the human relay became increasingly apparent. Obviously, a single human relay could not perform unaided any operation which was beyond the reach of her arm. Since each terminal requires a finite amount of space there was a limit to the number of channels which the operator could interconnect directly.

As soon as the number of channels exceeded this limit interconnection required the operation of two or more of these human relays in some sort of tandem operation. This necessity introduced difficulties and objections which increased with the number of relays in the tandem team. These difficulties and objections were mainly of two kinds—increasing risk of error and a slowing down in the speed with which connections could be made. Each relay in turn had to receive correctly the order given to the originating operator. Each such repetition enhances the chance of error. In the second place, since the operations of the human relay are relatively slow as compared with the time required by mechanical relays, the time required for a tandem operation, even if errorless, is appreciably longer than that required for a single operation.

Even before the time arrived when the multiplicity of channels to be interconnected had reached the point of requiring tandem operation, numerous automatic devices for doing some of the things originally required of the human relay had begun to develop as a result of scientific research. Developments along this line have proceeded steadily until today we are tak-

ing the last step and substituting an entirely automatic form of switching under the control of the originating subscriber as a means of performing all the acts required to establish connection between distant subscribers. As noted before, it may never, however, be possible or desirable completely to eliminate all the human operators from our intricate system.

Full electromechanical operation of the switching phenomenon has many advantages and some disadvantages, none of which I intend to touch upon. There is, however, one outstanding advantage in a city like New York, or other great metropolitan areas, in the fact that it makes very little if any difference in the time required to complete connections, whether the called party is in the next block or as far separated from the calling party as the uppermost parts of the Bronx are from Coney Island. In other words, it takes practically no longer to complete a connection from a Coney Island substation to one in the Bronx than it does to complete one in Coney Island. Thus in addition to an almost complete elimination of error on the part of the switching mechanism, we have also speeded up the time of completing connections.

Now, it is a curious fact in telephony that developments in the switching side of our business almost invariably find their first application in the local service, from which they spread gradually into the short and then into the longer toll services. On the other hand, advances which are made in the realm of transmission, which I am going to mention next, usually do exactly the reverse, that is, improvements destined ultimately to have wide application in the field of transmission make their first appearances in the longer circuits and, with increasing knowledge and increasing experience, spread into the shorter circuits.

While at first sight this may seem a somewhat curious effect, it is quite a natural phenomenon. It results from the fact that initial adaptations are usually more complicated and expensive

than they later become, with the result that their economic field is where maximum economies or advantages exist.

## The Channels of Communication

Passing now to channels of communication, let me tell you about a few things that have come directly and exclusively out of scientific industrial research. Initially the distances over which one could talk telephonically were very short and the number of people who wanted to use the telephone very small. The efficiency of transmitters and receivers was low and it was quite easy to make connection between stations using ordinary wires or pairs of wires whose dimensions were dictated mainly by mechanical considerations. Originally these wires were of iron, which was later superseded by copper when means were found to make copper relatively strong, because copper is a substantially better conductor than iron.

At first all the wires between central offices and the subscribers were placed on poles, much as you see them today on the poles which parallel our country roads or railroad rights of way. The individual wires, even though associated together in pairs, were separated a considerable distance from each other and were supported on insulators. As the number of channels increased, however, a limit of capacity was reached beyond which additional channels could not easily be provided by this type of arrangement. It became necessary to find some way to crowd these conducting channels closer and closer together. To make a long story short, out of this need science developed an entirely new arrangement which we call the telephone cable. You are doubtless all familiar with these cables, which have the appearance of lead pipes. In country and suburban districts they are hung from steel cables supported on poles. In cities and to some extent on country roads they are drawn into buried ducts under the streets—frequently you see them being installed in such location.

In these lead pipes are associated together vast numbers of

wires, each wire insulated from its neighbors by a thin wrapping of paper. All of these wires are associated together in pairs by a twisting operation and each pair constitutes a transmission channel. Electrical interference between these channels is prevented by a proper selection of twists, each pair being given a twist which is different from that of the surrounding pairs. In all of the pairs, however, the currents which flow are similar and have the same frequencies as those produced in ordinary speech. In such cables the ability to crowd many circuits together without cross-interference is obtained through a geometrical arrangement of the wires.

There is, however, an entirely different method which science has developed for crowding many channels of communication together in a small space without cross-interference. Before I tell you about this other way, let me first digress a moment and tell you something of the telephone repeater. This is an essential implement on all longer distance telephone channels.

It was long ago apparent that the limits over which commercial speech could be transmitted without some form of rejuvenation were rapidly being reached. This is because in any form of electrical transmission a certain amount of the initial energy is lost. As you progress along the channel there comes a point where the residual energy is not more than sufficient to operate the receiving apparatus commercially at its lower limit. This point marks, therefore, the limit of transmission over that particular type of channel. If one would go further some way must be found at this point or before it is reached, to add new energy to the current without, in the case of telephony, producing distortion which would render the speech unintelligible.

Out of this necessity, and again as a direct result of scientific research, came the development of the so-called telephone amplifier or repeater. With this instrument we can build up the weakened speech currents and send them on either directly to

their destination or, in the case of very long circuits, to successive additional repeaters which repeat the amplifying operation.

Where transmission is of ordinary voice frequency individual repeaters have to be provided for every channel at every point where amplification is required. If you go about the country along the main roads over which long distance circuits run you will find at intervals neat brick buildings. One such building you will find just outside of Princeton on the main highway to Trenton. These are the buildings in which telephone repeaters are housed. If you step inside you will find a vast quantity of vacuum tube apparatus, all of which resembles in appearance the inside of your radio sets. You will also find some form of power plant for supplying energy. All of the telephone circuits which require amplifiers are led through the apparatus in this building and there have new energy supplied to the speech currents passing through them.

Now to come back to the entirely different mode of transmission which I mentioned a few moments ago.

## The Application of Carrier Current Systems

With increasing scientific knowledge we have found a way, and in many situations what appears to be a better way, for carrying the intelligence of speech from one point to another over the longer distances and with many channels packed closely together.

Instead of using ordinary speech frequencies at every one of the number of parallel circuits between two points, we mix the ordinary speech current at the sending end with an artificially produced high frequency current which is above the range of audition. We can superimpose on the same conductor a considerable number of non-interfering transmissions, provided only that we use a different high frequency current for each transmission. When currents of two frequencies are thus mixed together the resultant frequency is a composite of the two, and when many of these composites are mixed together

for transmission over a single conductor the resultant current in the conductor is a composite of them all. We are not, however, interested particularly in what this composite is provided only that at the distant end of a line we can separate it into its elements and finally strain out the original speech currents and deliver each one to its proper recipient.

This we know how to do but time will not permit me to attempt a detailed explanation. In a way one might liken the operation at the sending end to the association together, in a common runway, of a large number of differently colored sheep, no one of which can reach the runway except through a particular gate. Within the runway all of the sheep move forward together and at the distant end each can find egress only through his own particular gate. Anything which we do along the runway to speed up the movement of the sheep speeds them all up equally. This whole system we refer to technically as a carrier current system.

Over certain kinds of conductors enormously wide bands of high frequency can be transmitted, bands up to one million cycles or more in width, that is, bands sufficiently wide to accommodate 300 or more speech channels, since the ordinary width of speech frequency bands used in telephony is in the order of 3000 cycles.

The fact that transmission between the terminals is in the nature of a single transmission means that at each point where amplification is required only a single amplifier is needed instead of individual amplifications for each channel to be operated on. Of course this single amplifier is different from the individual amplifiers but the fact that it is single offers great opportunities for simplification. At the point where this single amplifier is inserted the current which it operates on is infinitely complex. If one had an ear that could hear or an eye that could see within the circuit at this intermediate point he would apprehend simply a veritable Choctaw of electrical currents wholly unintelligible. In a sense it would be analo-

gous to observing the gyrations of the air particles in a crowded room where a vast number of people were talking together in pairs.

Most of you have probably seen in the papers in the last year or so reference to what is known as the coaxial cable. This cable, of which there is a trial installation at the present time under test between New York and Philadelphia, is a very simple mechanical structure. It is a small lead pipe in which there are two smaller copper tubes each about the size of a lead pencil and down the center of each of which runs a smaller copper wire which is insulated from its enclosing tube. Through each of these pipes, however, can go simultaneously hundreds of telephone messages transmitted in the general manner which I have just outlined to you. At each point where amplification is needed to revivify energy, all that is required is a single amplifier associated with each tube. At the receiving end of the circuit the separating operation is performed. This coaxial cable represents the present stage of development to which our research work in the realm of transmission has now brought us. It bids fair to open up some very considerable fields of utility.

This coaxial cable is now in the trial stage as to practical application but in the final stage as to the research and development features of its operation. It is a stage necessarily preliminary to use in a general commercial sense. This trial installation procedure is one which we follow religiously in all development work. When we have carried our research and development work as far as seems feasible in the laboratory we always supplement our work by a limited trial installation. This is necessary because there are certain things which cannot be learned within the confines of a laboratory. Such a trial in so far as it affects normal operation limits unanticipated difficulties in a way in which they could not be limited if we went directly from the laboratory to general use.

I have said that the coaxial cable development started in the

laboratory. Actually it started in the realm of mathematical analysis. It started back in the original work of Maxwell, Rayleigh and others, who considered mathematically the problems of transmission of electromagnetic waves in space. Gradually, through the increase in our knowledge of physics and mathematics, we came to understand that in this type of physical structure, if we could realize certain properties of matter on a commercial scale we would have a very simple form of transmission channel.

The question was, therefore, could we obtain commercially these properties which our mathematical analysis indicated to be necessary? Could we get material which would have this or that property? If so, would it act in this and that way? Considerations of this kind set the pattern, then, for the stages of laboratory development and marked out the experimental course to be followed. Taking the elements of the pattern one at a time and in proper order, we made progress gradually until we arrived finally at a stage where we could put them all together on a large scale laboratory experiment.

This coaxial cable is one of those developments which, as I indicated to you, will, when our field experiments have been completed, find its first application in the longer distances of telephony and over routes where the number of telephone channels is large. Unless past history fails to repeat itself in this case (and I have no reason to believe that it will) the distances over which we will find it economical to employ this general type of structure will tend to decrease. As time goes on and experience enlarges we are almost sure to develop better ways of doing things and better materials with which to do them.

Incidentally, this particular form of transmission channel has the unique advantage that if and when the much-talked-of television reaches the stage of wide commercial utilization it is easily adaptable to the type of transmission which will be required to carry the electric currents of television from point of

origin to the points where the impulses can be distributed to the ultimate user.

If in the future coaxial cables come to be used for shorter distances than those which are now indicated, it will but repeat the history of the older and simpler types of carrier current transmission which were not originally economical for anything less than distances of four or five hundred miles and with circuits employing a particularly fine grade of open wire facilities. Through continued intensive research and development we have during the past ten or fifteen years progressively reduced these distances until we now use carrier current methods on circuits as short as ten or fifteen miles. In the other sector, during this same period, switching mechanisms which were originally applicable wholly in local areas where concentration of service was heavy, have gradually spread out until we are today employing them for establishing many of our toll connections.

FRANK B. JEWETT